

Advances in Personality Theory and Research

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This paper briefly describes important advances in personality research that have been achieved during the past 20 years in the development of a fundamental personality typology and in the determination of the heritability of personality traits. Research conducted at the University of Ottawa that has contributed to the exploration of the biological bases of the extraversion trait is summarized.

Keywords: personality, extraversion, psychophysiology

Cet article décrit brièvement les développements importants survenus durant les 20 dernières années dans la recherche sur la personnalité, notamment quant à l'élaboration d'une typologie fondamentale de la personnalité et à la détermination de l'héritabilité des traits de personnalité. Il présente un résumé des travaux menés à l'Université d'Ottawa qui ont contribué à l'exploration des bases biologiques de l'extroversion en tant que trait de personnalité.

Mots clés : personnalité, extraversion, psychophysiologie

During the past 20 years, there has been significant progress in three important domains of personality research: personality classification, the heritability of personality traits and the biological bases of personality traits. A personality typology has been achieved in which sociability (extraversion; positive affect) and emotional stability (neuroticism; negative affect) emerge as robust superfactors in the large scale factor analysis of personality tests and items. There is also an emerging consensus on a third superfactor impulsiveness/constraint (psychoticism; toughminded; sensation seeking). What is remarkable is the widespread acceptance that this typology commands (Brand and Egan 1989). The heritability of these three dimensions has been confirmed and dramatically demonstrated in a series of studies that examined the concordance of personality traits for identical and fraternal twins raised together or apart, for close relatives, and for parents and their natural and adopted children. Research on the biological bases of

personality has not yet achieved the same dramatic success as work on the classification and heritability of personality. With our current knowledge of the biological bases of psychological processes and with the methods of physiological and neurochemical psychology that are presently applied in this endeavor, such success may be deferred for some time. Nevertheless, there have been some advances along this path. In the present paper, the current advances in the description and in the heritability of personality traits are briefly summarized. A perspective on the biological bases of personality that is the principal focus of our research program at the University of Ottawa is outlined and the implications of this work for personality theory are noted.

The Description of Personality

In expressing the objectives of the trait theory approach to personality description, it may be helpful to consider an analogy with color perception. One of the great successes in the classification of psychological experiences has been the development of a color space wherein all colors of the visible spectrum are described in reference to three hues,

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red, green and blue, and their variation along two dimensions, brightness and saturation. This classification scheme denotes, economically and precisely, the multiplicity of colors that have been ascribed evocative names such as forest green, azure, emerald and chartreuse. The color space has greatly facilitated research and application of color perception by providing a logical frame of reference that can be easily understood and communicated by scientists and engineers.

The problem of personality classification and the classification of color is essentially similar. There are thousands of adjectives, from abstemious to zealous, that denote personality characteristics; many of these terms are synonyms; some of the terms overlap in meaning to varying extent; other terms are antonyms. The challenge for the scientific study of personality has been to discover the fundamental personality dimensions that can order the multiplicity of personality descriptors and that serve as a universally accepted personality classification scheme. The development of factor analysis by Charles Spearman, beginning in 1904, enabled the pursuit of this objective by providing a method that reduces the thousands of terms that can describe personality to a few fundamental concepts. The first steps involved the construction of questionnaires and rating scales that quantified characteristics that were thought to be important elements of personality such as anxiety, depression, sociability, independence, succorance and so on. Until high speed computers became available in the 1960s, progress was painfully slow. The pioneering work of Cattell, Guilford and Eysenck converged during the 1970s in establishing extraversion and emotional stability (neuroticism) as reliable and replicable second order factors that were derived from the factor analysis of intercorrelated primary traits.

This period of development was not without controversy. First, several major attempts to replicate the factor structure of Cattell's 16 Personality Factor (16PF) test were unsuccessful. For example, Howarth (1972) administered the 187 item adult version of the 16 PF to 567 subjects and the data were submitted to item factor analysis. He obtained 10 interpretable factors that bore little relation to the 16 Cattell factors and he concluded "that the 16PF does not measure the factors which it purports to measure at the primary level". A similar investigation undertaken by Kline and Barrett (1983) was based on the item factor analysis of data from 491 subjects who completed Form A of the 16 PF. The authors used several different methods of factor analysis in the study. They stated that "even though five different factor solutions were rotated to a maximum simple structure, the sixteen factors did not emerge as expected." They concluded that "from a consideration of all the results presented so far, . . . Cattell's 16 factors were not represented in this sample data using Form A of the 16 PF Questionnaire." However, both Howarth (1972) and Kline and Barrett (1983) reported that the three factors of the *Eysenck Personality Questionnaire* (EPQ), Extraversion, Neuroticism and Psychoticism (tough-mindedness), clearly emerged in their studies. These findings are also supported in indepen-

dent research by McKenzie (1988). The independent factor structure of the Extraversion, Neuroticism and Psychoticism dimensions are illustrated in Table 1 with data from Stelmack et al (1983) reporting a factor analysis of the EPQ scales and the subscales of the Sensation Seeking Scale.

Table 1
Varimax-rotated factor matrix for EPQ and SSS scales (N = 144)

Personality scale	Factor I	Factor II	Factor III
Extraversion	-0.06	0.81	0.05
Neuroticism	-0.16	0.19	0.61
Psychoticism	0.58	0.06	0.10
Lie	-0.13	0.10	0.38
Boredom Susceptibility	0.52	0.10	0.02
Disinhibition	0.42	0.34	0.06
Experience Seeking	0.50	0.10	-0.11
Thrill and Adventure Seeking	0.23	0.36	0.12

There has also been some debate concerning the primary factors that contribute to the extraversion dimension (Guilford 1977, Eysenck 1977). The similarities and differences in the schemas developed by Eysenck and Guilford were examined by Campbell and Reynolds (1984). An important finding was a convergence in identifying Extraversion (sociability) and Neuroticism (emotional stability) as independent (uncorrelated) second order factors.

Evidence endorsing the view that Extraversion (E), Neuroticism (N) and Psychoticism in Eysenck's typology are fundamental descriptive concepts can be drawn from several sources. Factor analysis of the *Minnesota Multiphasic Personality Inventory* (MMPI), a well known test that was developed for use in mental health settings, revealed a correspondence with the EPQ dimensions (cf. Wakefield et al 1974). The MMPI scales were empirically derived from psychiatric classifications. There are several scales that refer to neurotic and psychotic disorders and another to social introversion. If the EPQ typology is fundamental, there should be a concordance between E, N, and P and the MMPI scales that correspond conceptually to those dimensions. Wakefield et al (1974) have confirmed this correspondence. The authors note that the MMPI was not developed to correspond to Eysenck's personality theory. They conclude that "the geometric correspondence between the inventory and the theory suggests that the theory has a reality apart from the test construction skills of the theorist."

The fundamental nature of the E, N, and P typology is also supported by longitudinal research and by a series of cross cultural studies. First, there is good evidence that personality traits E, N and P are relatively stable characteristics across the adult life span (Conley 1984, Costa and McCrae 1980). In contrast, self-opinion variables such as feelings of well-being, life satisfaction and self-esteem do not show the same degree of consistency across the life span. This work suggests that the personality variables are more stable, and less influenced by life experience, than are self-opinion variables. In cross cultural research, the EPQ

has been translated into 26 different languages. The translations were prepared using back-translations to ensure correct meaning. Items that were colloquial or untranslatable were replaced by items that were consistent with the meaning of the primary factor of interest. Factor analysis and factor comparisons using data from large samples ($N > 500$) have determined that the orthogonal (uncorrelated) factor structure of the dimensions and the factor loadings of the translated tests were highly similar to the standardized test (cf. S.B.G. Eysenck 1983). In our own research, we have shown that a French translation of the EPQ is comparable to the English version when administered to a large Canadian sample. Overall, this cross-cultural research clearly indicated that the personality factors E, N, and P are identified in those countries studied so far and thus are not culturally specific.

The fundamental nature of the Extraversion, Neuroticism and Psychoticism dimensions is also underscored in an important series of studies on the rating of personality traits. With the rating method, subjects are asked to indicate the degree to which adjectives on a bipolar scale are descriptive of themselves. There are a number of problems encountered in the factor analysis of personality trait ratings that have encumbered the task of revealing basic dimensions of individual differences. These problems include the determination of techniques for estimating communalities, for specifying the number of factors to be extracted, and for rotating the factors to the most appropriate simple structure. There is also some debate concerning the interpretation and naming of factors. Despite these problems, and despite differences in the factor analytic procedures applied, there has been a remarkable consistency in the results obtained. An important finding was reported by Norman (1963) who identified five highly replicable factors in the analysis of 20 bipolar adjective scales. These factors have proven to be very robust. In a recent review, Digman and Inouye (1986) state: "A series of research studies of personality traits has led to a finding consistent enough to approach the status of a law. The finding is this: If a large number of rating scales is used and if the scope of the scales is very broad, the domain of personality descriptors is almost completely accounted for by five robust factors." The five factors identified by Norman were Extraversion, Agreeableness, Conscientiousness, Emotional stability and Culture.

Highly similar factors have been identified in the factor analysis of personality inventory scales rather than ratings (Block 1977, McCrae and Costa 1987). There remains some controversy among these authors concerning the precise meaning of some factors, especially Culture, Openness to experience, Intellect, and Independence of opinion, factors that have at least some nominal correspondence with Eysenck's Psychoticism scale (toughminded; insensitive to the feelings of others).

There is a considerable consensus that there are a limited number of factors that consistently emerge in the factor analysis of personality descriptors. Moreover, there are compelling demonstrations reporting essentially similar

factor structures in the analysis of the ratings of adjectives obtained from subjects who were asked to rate acquaintances and from subjects who were asked to rate strangers (Passini and Norman 1966). Also, when subjects were asked to rate the similarity of meaning of the adjectives used by Passini and Norman, the factor structure obtained was essentially identical to that obtained from the ratings of strangers and acquaintances. This work raised the question of whether this universal conception of personality structure actually reflected the structure of personality. Or alternatively, whether this structure only exists in the minds of the raters and reflects the semantic similarity relations among the trait descriptive terms. This question has been recently investigated by examining the meaning relationships between personality attributes and between the same universe of observed behaviors or acts (Borkenau 1988). Specifically, acts that exemplified or were considered typical of each of the 20 Norman adjective scales were determined. For example, the statement "He lent his car to a colleague" is a prototypical act for cooperative. Independent judges then rated 120 such statements on each of the 20 adjective scales. The analysis of the meaning of behavioral acts yielded essentially the same five factors leading the author to conclude that "the five major factors of personality reflect basic dimensions of meaning that underlie the attribution of traits on the basis of the observation of behavior."

The Heritability of Personality

Several large scale studies in quantitative behavioral genetics have endeavored to assess the contribution of genetic and environmental determinants to differences in personality. The personality traits that have been investigated most extensively and successfully are Extraversion and Neuroticism (Loehlin 1989, Eysenck 1990) but a wide range of temperament traits and social attitudes were also analyzed. Although the methods employed in these inquiries are inferential rather than experimental, the findings are compelling and the implications of this work for the understanding of personality traits are profound.

The basic strategy for this research involves an analysis of kinship relations, particularly the comparison of identical and fraternal twins. The rationale for this method was developed by the English polymath, Francis Galton, the inventor of the correlation coefficient, the teletype machine, and the word association test. Basically, it is argued that if identical twins are more similar than fraternal twins on a particular trait, the trait is influenced by genetic factors. The comparison of identical and fraternal twins raised together with twins raised in different families allows the effects of common environment to be assessed. The comparison of adopted children with their biological and adoptive relatives also enables contrasts of genetic and environmental influences on the expression of personality traits. Overall, there is a good deal of consistency between early research on this subject that reported intraclass correlations

for small samples of twins reared together and apart and the recent complex model fitting analyses applied to twin data from large samples. The scale of the contemporary research is especially impressive as it comprises monozygous and dizygous twin populations of 500 from the UK (Eaves et al 1989), 900 from the USA (Loehlin and Nichols 1976), 4000 from Australia (Martin and Jardine 1986), 13,000 in Sweden (Floderus-Myrhed et al 1980) and 14,000 in Finland (Rose et al 1988).

The data from these studies converge in their conclusion that about 50% of the variation in personality, specifically extraversion/sociability, neuroticism/emotional stability and psychoticism can be attributed to genetic influences (Eysenck 1990). The remaining 50% of the variation in these traits can be accounted for by unique, individual effects of environment and measurement error. Although environment contributes significantly to the determination of personality, an important result of this research is the observation that the common family environment that twins share does not contribute substantially to variation in personality (eg. Plomin and Daniels 1987).

These views are best illustrated by an important study of identical and fraternal twins raised in different families that was conducted at the University of Minnesota (Tellegen et al 1988). Their data show that the intraclass correlations for the identical twins reared together (N=217 pairs) and twins reared apart (N=44) were greater than for the dizygotic twins reared together (N=114) and reared apart (N=27) on the three major personality factors, results that are attributed to genetic influences on personality. Overall, the correlations between the identical twins reared apart were highly similar to the correlations observed for the identical twins reared together. Only the positive emotionality factor (extraversion) showed some modest influence of common family environment, with the intraclass correlations for the twins reared together displaying a greater degree of association than the twins reared apart. For negative emotionality (neuroticism) and constraint (psychoticism reversed), the estimates of variance attributed to shared family environment were negligible. This finding is remarkable because twins share many environmental conditions that have been thought to influence personality development including parental attitudes, values, education, beliefs, social class and common school, friends and family experiences. Table 2 shows the

data reported by Tellegen et al (1988) presenting estimates of the proportion of genetic and environmental (shared family and unshared) variance for Positive emotionality, Negative emotionality and Constraint.

The Biological Bases of Personality

The notion that temperament is influenced by biological states is a view that can be traced to ancient Greek physicians such as Hippocrates and Galen who ascribed various moods and maladies to differences in bodily fluids (Stelmack and Stalikas 1991). This view has been affirmed by evidence from the biometric analysis of personality descriptors that demonstrates the heritability of several personality traits, including extraversion, emotional stability, and conservatism (Fulker 1981, Tellegen et al 1988), from biochemical assays that link such traits as extraversion, sensation-seeking and impulsiveness to differences in neurohumoral and catecholamine activity (Demisch et al 1982, Schalling et al 1988), and from psychophysiological measurements that refer differences in extraversion, sensation-seeking, and impulsiveness to differences in physiological arousal systems (Stelmack 1981, 1990). This work underscores the appropriateness and promise of determining the biological mechanisms that contribute to individual variation in the fundamental personality dimensions. This objective has been a primary focus of my research program at the University of Ottawa.

The conceptual framework that has guided our research program is one that is adopted in several prominent contributions to the study of personality traits, notably extraversion (Eysenck 1967), anxiety and impulsiveness (Gray et al 1983), sensation-seeking (Zuckerman 1979), and the Pavlovian typology of the nervous system (Strelau 1983). At both the descriptive and explanatory levels, these contributions display marked similarities. Although our previous work has addressed issues raised by all of these authors, our research has focused, to a large extent, on the extraversion trait. It is this trait that has proven to be most amenable to investigation with psychophysiological measurement techniques.

In 1967, Eysenck developed an hypothesis that outlined plausible physiological mechanisms which could mediate the differences in sociability and impulsiveness that define the extraversion trait. Specifically, it was proposed that introverts are characterized by lower thresholds of arousal in the ascending reticular activating system (ARAS) than extraverts. The influence that the ARAS exercised on cortical activity made this system an appropriate choice for explicating the individual differences in sensory sensitivity (Stelmack and Campbell 1974, Kohn 1987, Dornic and Ekehammar 1990), attention (Gange et al 1979), conditioning (Jones et al 1981) and memory (Stelmack et al 1984) that were demonstrated and that were conceived as precipitating processes for both the social and psychiatric behaviors that the extraversion trait distinguished.

Table 2
Estimates of genetic and environmental variance components from personality questionnaire data of twins reared apart and together

Scale	Variance component		
	Genetic	Shared Familial	Unshared
Positive Emotionality	.40	.22	.38
Negative Emotionality	.55	.02	.43
Constraint	.58	.00	.43

Note: Adapted from Tellegen et al. (1988), *Journal of Personality and Social Psychology*, 54, 1031-1039 with permission of the authors.

In this context, our research program has contributed to the evaluation of this hypothesis through the application of various psychophysiological recording procedures, including electrodermal (Stelmack et al 1979, Stelmack et al 1985) and pupillometric (Stelmack and Mandelzys 1975, Plouffe and Stelmack 1979) measurement of autonomic nervous system activity and event-related potential (ERP) measurement of electro-cortical activity (Stelmack et al 1977, Stelmack and Michaud-Achorn 1985, Stelmack and Wilson 1982). Several reviews of this subject area have been published that addressed both substantive and technical issues (Stelmack and Geen in press, Stelmack 1990, 1985a, 1985b). The outcome of this work can be summarized as follows: There is a good deal of evidence from both electrodermal (cf. Smith 1983) and event-related potential (Stelmack et al 1977, Bruneau et al 1984) recording procedures that introverts exhibit greater reactivity to stimulation than extraverts. These effects are illustrated in Figure 1 with ERP waveforms to high and low frequency tones of 80 db intensity, showing the enhanced ERP amplitude of introverts to low frequency tones. In general, the evidence is consistent with the enhanced sensitivity to stimulation for introverts that is reported across all sense modalities (Kohn 1987) and, overall, endorses the arousal hypothesis.

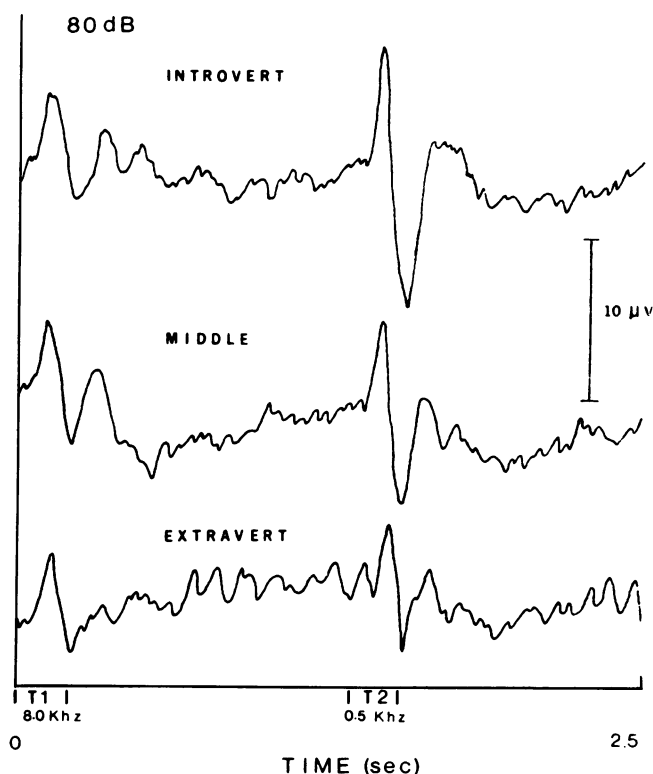


Fig. 1. Auditory event-related potential waveforms to high (8.0 KHz) and low (0.5 KHz) frequency tones of 80 db intensity for groups (N=10) of introverts, middle and extraverts.

In proposing the arousal hypothesis, Eysenck (1967) did not make a clear distinction between tonic (base level) arousal and phasic (response level) of arousal. While differences in response to stimulation are evident, there is no clear evidence of differences in tonic or base level of arousal (Stelmack 1990). Further, there is no clear evidence that differences in sensitivity to stimulation, as observed with psychophysical (Stelmack and Campbell 1974) or event-related potential measures (Stelmack and Michaud-Achorn 1985) are determined by differences in attentional state. The absence of differences in base level of cortical or autonomic activity and the failure to observe differential effects of attention suggest that differences in sensitivity to stimulation may be a result of differences that involve primary sensory processes.

The above conclusions do converge with evidence of faster auditory brainstem evoked responses (BER) for introverts than extraverts (Stelmack and Wilson 1982), effects that are specifically determined by activity of the auditory nerve and cochlear nucleus (Buchwald and Huang 1977) and that are directly related to perceived loudness (Wilson and Stelmack 1982). These findings implicate differences in peripheral nervous system processes that are not determined by mechanisms in the ARAS as proposed in the arousal hypothesis and require an elaboration of the neurological bases of extraversion to accommodate differences in neuronal transmission that are present in peripheral nervous system processes.

Both introverts and extraverts and high and low sensation-seekers display differences in the expression of motor behaviour. For example, extraverts and sensation-seekers tend to be more impulsive, more physically active, more involved in contact sports, (Zuckerman 1983, Eysenck et al 1982) and more restless in restricted environments (Gale 1969). Since these differences in the expression of motor behavior cannot be readily accounted for in terms of the mechanisms mediating the differences in sensory sensitivity that have been outlined, we have investigated some procedures for examining discrete physiological motor mechanisms. In previous work, we have demonstrated that subjects with high scores on the extraversion scale and on the disinhibition subscale of the Sensation-seeking Scale exhibit reduced motoneuronal excitability as determined by analysis of reflex recovery functions (Pivik et al 1988). Specifically, pairs of percutaneous stimuli are applied to the tibial nerve and evoked muscle action potentials are recorded from the calf muscle. The pairs of equal intensity stimuli are presented at inter-pair intervals of 40 to 2000 msec. Reflex recovery is expressed as a ratio of the reflex amplitude of the second stimulus in the pair to the reflex amplitude of the first stimulus of the pair. Figure 2 shows the greater reflex recovery of introverts than extraverts obtained with this procedure. These results refer differences in extraversion and sensation-seeking to discrete levels of motor system activity that mediate muscle activity and motor control. Decreased motoneuronal excitability, as indexed by reflex recovery function measures, has been linked to increased

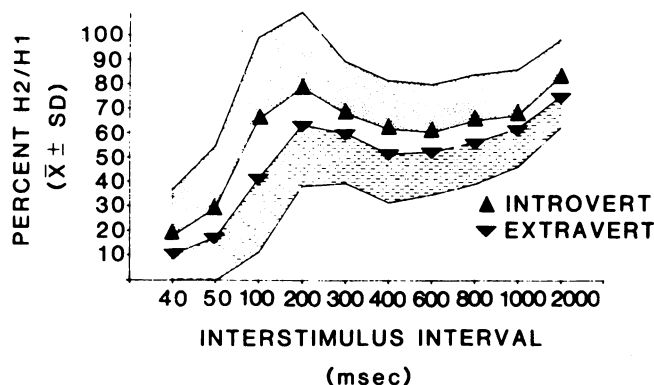


Fig. 2. Reflex recovery functions for introverts (n=23) and extraverts (n=36) derived from pairs of brief electrical pulses applied to the tibial nerve at interstimulus intervals of 40 to 2000 msec.

dopaminergic activity. Thus, the effects observed converge with the observation of low levels of monoamine oxidase and dopamine-beta-hydroxylase for extraverts and high disinhibition subjects (cf. Zuckerman 1989). Those neuro-regulators can be associated with increased dopaminergic activity. Overall, the results of this study are very encouraging; they can be seen to challenge the emphasis on stimulus-seeking arousal mechanisms that are presently supposed to serve individual differences in sensation-seeking (Zuckerman 1984). These data invite one to focus on the seeking, that is the motor aspect of sensation seeking and extraverted behaviour, rather than sensation or the need for stimulation to restore arousal systems to an optimum level.

CONCLUSION

During the past 20 years, there has been deliberate progress in the development of a personality typology that, in particular, identifies extraversion (sociability) and neuroticism (emotional stability) as independent, fundamental dimensions of personality description. Compelling evidence has been put forth indicating that 50% of the variation along these dimensions can be attributed to genetic influences. There is now a good deal of interest in determining the biological systems that dispose the expression of these traits. Our work on the psychophysiology of Extraversion at the University of Ottawa has provided evidence that endorses the plausibility of the biological bases of this trait, that identifies the conditions under which reliable effects may be observed and that focusses the neurological systems implicated in the extraversion trait. It is acknowledged that extraversion is expressed in a broad range of social and psychiatric behaviors, including patterns of sexual attitudes, preferences and performance (Wilson 1981), appreciation of humor (Nias 1981), study habits (Campbell and Hawley 1982), educational achievement (Wankowski 1973), incidence of antisocial behavior (Eysenck and Gudjonsson

1989) and effectiveness of counselling and psychotherapy (Di Loreto 1971) to list only a few of these. Elaboration of the biological systems that contribute to the variation in degree of Extraversion is an important research goal that promises to enhance our understanding and appreciation of those differences.

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